

Diversity of scorpions (Chelicerata: Arachnida) in the Atlantic Forest in Pernambuco, northeastern Brazil

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ABSTRACT: This study was conducted to measure the biodiversity of scorpion species in the remnants of the Brazilian northeastern Atlantic Forest, an important center of biodiversity and endemism. Collections were performed in twelve forest fragments in Sirinhaém municipality, Pernambuco State, through active searches at night by using UV lamps between 19:00h and 21:00h during the new moon phase in December 2012 and January 2013. A total of 1,125 specimens from two genera and five species were collected: *Tityus pusillus* Pocock, 1893; *Ananteris mauryi* Lourenço, 1982; *Tityus brazila* Eickstedt & Lourenço, 1984; *Tityus neglectus* Mello-Leitão, 1932; and *Tityus stigmurus* (Thorell, 1876), all belonging to the family Buthidae C.L. Koch, 1837. The most abundant species was *T. pusillus* (90.7%), followed by *A. mauryi* (7.1%). *Tityus brazila*, *T. neglectus*, and *T. stigmurus* together represented less than 3% of the individuals sampled.

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INTRODUCTION

There are approximately 1,900 known species of scorpions (Stockman and Ythier 2010) that are distributed worldwide except in Antarctica (Sissom 1990). Approximately 50% of these species occur in Neotropical regions (Lourenço 2002a), including Brazil, where roughly 130 species are recorded (Porto *et al.* 2010). Although scorpions constitute a successful group of invertebrates in all environments where they live, the group is poorly sampled and little is known about their diversity in most ecoregions, particularly in the Brazilian Atlantic forest (Dias *et al.* 2006). The Brazilian Atlantic Forest, an important center of biodiversity and endemism, has suffered a significant loss of its native vegetation cover and currently has only a few remnant fragments of its original forest. These fragments are isolated from one another and are mostly surrounded by crops or pasture land (Mittermeier *et al.* 2005). Approximately 83% of the remnant fragments are <50 ha and only 1% are >100 ha (Ribeiro *et al.* 2009). They are composed of secondary forests with different levels of regeneration (Ribeiro *et al.* 2009). Although predators regulate many arthropod populations and can be food for invertebrates and vertebrates (Polis 1990), few ecological surveys highlighting scorpion species composition in the remnants of the Atlantic Forest have been performed (Dias *et al.* 2006; Yamaguti and Pinto da Rocha 2006; Bertani *et al.* 2008; Porto *et al.* 2010; Lira *et al.* 2013; Porto *et al.* 2013). Most studies on arthropod diversity in this environment have been restricted to insects (Santos *et al.* 2012; Souza *et al.* 2013), spiders (Melo *et al.* 2011), and harvestmen (Resende *et al.* 2012a, 2012b).

Since no taxonomical or ecological records on scorpion fauna were available from the Brazilian northeastern

Atlantic Forest region, we surveyed the scorpions from twelve fragments of Atlantic Forest in Pernambuco to expand the knowledge of the scorpion fauna of this region. The study was performed in the fragments belonging to Trapiche Mill as part of the project for the protection of its fragments. The data from the present work provide information for the continued maintenance of the remnants of the Atlantic Forest in Pernambuco.

MATERIALS AND METHODS

Study Area

Field work was conducted in twelve fragments in the municipality of Sirinhaém (8°35'27" S, 35°06'58" W), in the state of Pernambuco (Figure 1). Fragments, which are surrounded by sugar cane, ranged from 6 to 469 ha and were located at elevations of 20 to 120 m above sea level. The area is characterized by a mean annual temperature of 25°C and an annual rainfall of 2,400 mm (Silva *et al.* 2010). We collected samples during the dry season. The Trapiche Mill owns approximately 4,000 ha of dense ombrophilous rainforests. According to the Trapiche staff, remnants in this area have been under the landowners' protection over the last 10 years. This region is located in the 'Pernambuco Endemism Center' (PEC), situated north of the São Francisco River, in the states of Alagoas, Pernambuco, Rio Grande do Norte, and Paraíba.

Data collection

Six transects that were 20 m apart were used as sampling units in each Trapiche fragment, making a total of 72 sampling units. Each transect was 30 m long and placed randomly at least 200 m from the remnant edge. The scorpions found up to 5 m from either side of each transect were collected resulting in a 300 m² sampling

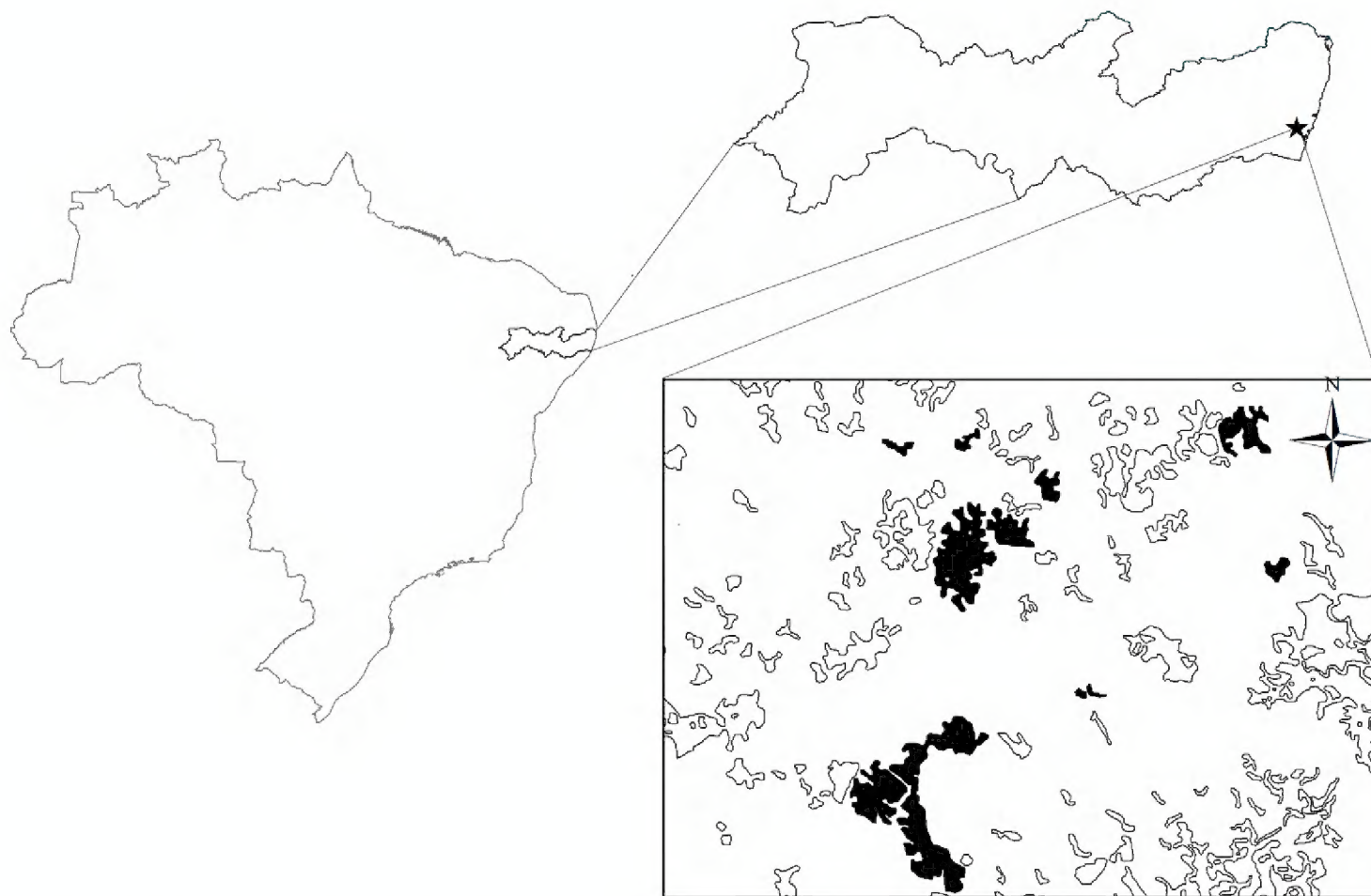


FIGURE 1. Map showing the distribution of forest remnants in Trapiche Mill and the position of the 12 studied fragments.

area. The scorpions were located by actively searching for them between 19 h and 21 h for one night for each remnant. Each transect was covered twice (round-trip) for 1 h by a pair of collectors equipped with ultraviolet lights (Figure 2). Active searches were made during the new moon phase, from December 2012 to January 2013 (the dry season). Each scorpion collected was individually stored in a vial containing 70% ethanol. The specimens were identified according to Lourenço (2002b). Voucher specimens (CA-UFPE #601 to 623) were deposited in the Arachnological Collection of the Universidade Federal de Pernambuco, Recife. All scorpions were collected by the permission of Instituto Chico Mendes de Conservação de Biodiversidade (ICMBIO) #36336-1. The data corresponded to active individuals in the leaf litter, barks, logs, and bromeliads. Specimens were either outside or just emerging from the refuges, as suggested by McReynolds (2008).

RESULTS

A list of species and their occurrences is presented in Table 1. A total of 1,125 scorpions were collected. They were from two genera and five species, all belonging to the family Buthidae C.L. Koch, 1837. Four species were from the genus *Tityus* C.L. Koch, 1836 (*T. brazila* Lourenço & Eickstedt, 1984; *T. pusillus* Pocock, 1893; *T. neglectus* Mello-Leitão, 1932; *T. stigmurus* (Thorell, 1876) and one belonged to the genus *Ananteris* Thorell, 1981 (*A. mauryi* Lourenço, 1982). Photographs of the collected species are shown in Figures 3 and 4. *Tityus pusillus* and *A. mauryi* were recorded in all twelve fragments (Table 1). The former was the most common species, representing 90.7% of the total collected scorpions, followed by *A. mauryi*, representing 7.1%. The other three species together represented only 2.2% of the scorpions collected. The least common species was *T. stigmurus*, which was found only in one fragment. No single fragment had more than three scorpion species (Table 1).

Tityus pusillus and *Ananteris mauryi* were collected



FIGURE 2. Scorpion individual under ultraviolet radiation. Photo by André F. A. Lira.

exclusively in the leaf litter, while *T. brazila* was found under bark in cracks, and inside their retreats showing extended pedipalps and open chela. *T. neglectus* and *T. stigmurus* were found in logs and leaf litter.

DISCUSSION

In northeastern Brazil, 28 species of scorpions are found. Sixteen species have been recorded in the Atlantic Forest (Lourenço 2002b, Dias *et al.* 2006; Porto *et al.* 2010). In this study, one-third of these species was found in Pernambuco. Dias *et al.* (2006) found four scorpions species in an urban Atlantic Forest fragment, all of which were also found in this study.

Tityus pusillus was the most common species in all fragments analyzed in the present work. The sedentary habit and microhabitat preference of the surface litter of this species are in agreement with Lira *et al.* (2013) and may facilitate sampling by active search, making this species more visible and easier to capture. *Tityus pusillus*

has also been recorded in the Atlantic Forest of Bahia (Porto *et al.* 2010, Brazil and Porto 2011) and Paraíba (Dias *et al.* 2006), as well as in the Caatinga (Bahia and Piauí) (Porto *et al.* 2010, Brazil and Porto 2011). These findings indicate a wide distribution of this species in the

northeast region and a high ecological plasticity, since they were recorded from different environments such as rain forest and dry forest.

Ananteris mauryi, the second most common species in the present work, shows an errant habit, inhabiting the lower layers of leaf litter, as described previously by Lira *et al.* (2013). They also show metasomal autotomy (Lira *et al.* 2014). This species was originally described from PEC. Later, it was found in the states of Bahia and Sergipe (Lourenço 2002b; Brazil and Porto 2011). Using



FIGURE 3. *Tityus* species collected in this study. A. *Tityus brazilaie* B. *Tityus neglectus*, C. *Tityus pusillus* and D. *Tityus stigmurus*. Photographs A-C by Adriano M. DeSouza and D by André F. A. Lira.

TABLE 1. Number of individuals, species of scorpions, and fragment size (in hectares) of each of the twelve studied fragments. Mata das cobras (MC), Pedra do cão (PC), Tauá (TA), Canto escuro (CE), Ubaca (UB), Canto escuro 2 (CE2), Xanguá (XA), Xanguá 2 (XA2), Franco 1 (FR1), Franco 2 (FR2), São Pedro (SP), and Baquinha (BA).

FRAGMENTS	AREA	SCORPION SPECIES				
		<i>Ananteris mauryi</i>	<i>Tityus brazilaie</i>	<i>Tityus neglectus</i>	<i>Tityus pusillus</i>	<i>Tityus stigmurus</i>
FR2	6.43	3	—	—	55	4
FR1	8.27	16	—	—	37	—
BA	10.53	3	—	—	37	—
CE2	18.52	2	—	5	86	—
UB	20.67	2	2	—	7	—
PC	33.51	1	—	—	47	—
MC	46.08	9	1	—	173	—
CE	75.80	6	—	1	50	—
SP	120.70	10	2	—	96	—
XA2	197.52	4	3	—	177	—
TA	280.33	9	—	—	2	—
XA	469.76	20	—	1	150	—
Total		85	8	7	920	4

pitfall traps to sample scorpions in Mata do Buraquinho, a fragment of the Atlantic Forest, Dias *et al.* (2006) found that *A. mauryi* was the most abundant species. Although dominance changes are normal within the distribution of the species, differences in sampling methods may account for the variation observed in these studies because errant behavior may favor capture by pitfall traps.

Tityus brazilae was found in four out of the twelve fragments. A previous study reports its presence in the Atlantic Forest from Rio de Janeiro to Paraíba (Brazil and Porto 2011). We observed a sit-and-wait behavior with extended pedipalps and open chela, which corroborated with the observations of Lira and DeSouza (2014). Despite their large size (50–70 mm) (Lourenço 2002b), this behavior makes them difficult to be seen and captured. Therefore, it is likely that their presence and abundance are underestimated.

Another large species (54–78 mm), *Tityus neglectus*, was found in three out of the twelve fragments. This species has a wide distribution in the northeast, and occurs from the state of Bahia to Rio Grande do Norte (Lourenço 2002b; Santos *et al.* 2003; Dias *et al.* 2006). It is associated with bromeliads and soil (Lourenço and Eickstedt 1988; Santos *et al.* 2003). Despite the specificity of its microhabitat described in the literature, specimens collected in this study were collected from the leaf litter or logs. This suggests that sampling may have occurred during the reproductive period when individuals leave their microhabitats in search of mates. We also collected more males than females, which supports this hypothesis (data not shown).

Tityus stigmurus was the least common species and it was collected from the smallest fragment. Which may represent the less conserved. As a synantropic scorpion, this species may be adapted to a more disturbed environment. This species is found in most northeastern states of Brazil and Minas Gerais (De Souza *et al.* 2009; Brazil and Porto 2011). It has been responsible for the highest number of scorpion stings in the region, including child mortality (Albuquerque *et al.* 2013).

Despite the great difference in size of the fragments, there were no distribution patterns among scorpions. No scorpion species was found only in the larger fragments and no fragment contained more than three species. Unlike other groups, such as dung beetles and ants, where the fragment size is important for species richness (Filgueiras *et al.* 2010; Leal *et al.* 2012), environmental quality seems to be more important for scorpions. However, further studies are needed to confirm this.

Polis (1990) suggests that the presence of six species is an indicator of high scorpion diversity. Therefore, the five species reported in the Trapiche landscape suggests high scorpion richness in this area. This fact underscores the importance of conservation of forest remnants to maintain scorpion fauna. Thus, the results presented here contribute to the knowledge of the diversity of scorpions in the Atlantic forest of Pernambuco and can serve as a basis for future research on the impact of fragmentation on the population, distribution, and ecology of scorpions.



FIGURE 4. *Ananteris mauryi* specimen. Photograph by Arthur Costa.

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